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A method for producing a molded body made of sintered steel

1. Field of the invention

The invention relates to a method for producing a molded body made of sintered steel, with a sintering powder on the basis of iron being mixed with a master alloy powder containing nickel, boron and iron and with the powder mixture being pressed into a formed body before the formed body is sintered under the conditions of a liquid-phase sintering with a volume share of liquid phase up to 15%.

2. Description of the Prior Art

During the compacting of sintered steel by liquid-phase sintering by using a master alloy powder made of nickel and boron, the nickel diffuses into the iron powder at the latest after the first occurrence of melt. The iron dissolves partly in the liquid phase and any present nickel boride is converted into iron boride which at least at temperatures above the iron-boron eutectic reacts again with iron by forming a liquid phase, so that the liquid phase increasingly encloses the body of the iron powder. The increase of the liquid phase during the sintering leads to a reduction of the pores and thus to a compacting of the sintered steel. Since the quantity of the liquid phase is determined predominantly by the content of iron in the liquid phase, it has already been proposed (T. Nishida, T. Yamazaki, S. Chida, M. Yamamiya: Effect of B on the Densification and the Mechanical Properties of Sintered Iron Powder Compacts, J. Japan Inst. Metals, Vol. 54, No. 10 (1990), pp. 1147-1153) to use a master alloy powder made of iron, nickel and boron, thus providing additional iron boride through the prealloy, leading to an acceleration of the reactions which leads to an increase in the volume of the liquid phase. Netlike eutectic structures are formed which increase the tensile strength of the sintered steel, but have a serious negative effect on the impact strength in particular.

These connections were examined with a master alloy powder with 20% by weight of iron, 70% by weight of nickel and 10% by weight of boron as alloy components. The share of the master alloy powder in the powder mixture made of master alloy powder and iron powder was 3 to 7% by weight. Whereas the iron powder had an average particle size of 80 μm , the average particle size of the master alloy powder was approximately 4 μm in order to obtain an improvement concerning the impact strength. Apart from the fact that the production of such master alloy powders is complex because the required prealloys are molten first and then atomized and then fractured by exciting vibrations before an average particle size of 4 μm or finer is obtained by a respective grinding process, the impact strength of the sintered steels obtained with the help of these master alloy powders remains unsatisfactory.

Summary of the invention

The invention is thus based on the object of providing a method for producing a molded body made of sintered steel of the kind mentioned above in such a way that especially the impact strength of the sintered steel can be increased decisively.

This object is achieved by the invention in such a way that the boron content of the powder mixture is between 0.03% and 0.2% by weight at a boron share of the master alloy powder of less than 10% by weight, that the weight ratio between the nickel and the boron share of the powder mixture exceeds 5 and that the master alloy powder has an average particle size of between 10 and 90 μm .

As a result of the cooperation of these measures, the establishment of a continuous eutectic net structure can be suppressed in a surprising manner, as is desirable for a substantial compacting of the sintered steel. This means that the molded body shows favorable values concerning the impact strength, namely with respectively high tensile strengths as a result of the higher density, even though a certain residual porosity needs to be accepted due to the mutually delimited boride regions.

Although it can be assumed that the thickness of the boride layers produced during the sintering will increase with coarser particles of the master alloy powder and thus the probability of an interconnected boride net will increase, it is possible to gain advantages concerning the suppression of a marked boride network by a mean fineness of the master alloy powder (average particle size between 10 and 90 μm) in comparison with fine powders because they preferably comprise rounded edges through coarser master alloy powder obtained through gas atomization, have a lesser tendency towards agglomeration and can be mixed more evenly with the sintering powder on the basis of iron. This fact leads in connection with the limitation of the boron content in the entire powder mixture to 0.03 to 0.2% by weight and to the thus following delay in the grain growth at a respective choice of the sintering temperature to a sufficient obstruction in the growing together of local boride regions in order to prevent the formation of an interconnected boride network. It is necessary to ensure a sufficient nickel share in the powder mixture since nickel ameliorates the effect of the boron concerning embrittlement of the sintered steel. With a ratio between the nickel share and the boron share in the powder mixture of at least 5, a respectively reduced boron content can be used due to the sinter-supporting effect of the nickel, which is of considerable relevance for the avoidance of an interconnected boride network.

At a boron content of 0.03% in the powder mixture, it is possible to notice a respective influence on the sintering with respect to improved impact strength of the sintered steel under the required conditions. Especially favorable conditions are obtained in this connection when the boron content of the powder mixture is between 0.10 and 0.15% by weight because the likelihood of an interconnected boride network can be substantially excluded at these boron contents.

The carbon required for the hardening of a sintered steel is usually added in the form of graphite. The carbon impairs the advantageous effect of the boron on the sintering process, so that it is recommended to limit the carbon content to a value of between 0.15 and 0.8% by weight.

The described effects of the measures in accordance with the invention do not depend on the composition of the sintering powder on the basis of iron, so that the composition of this sintering powder can be chosen according to the respective requirements. The master alloy powder is also not limited to a ternary alloy. The master alloy powder can additionally contain manganese, chromium, copper, molybdenum, vanadium, titanium, niobium, tungsten, carbon, aluminum and/or at least one element from the group of the lanthanides.

In one embodiment, a master alloy powder with 67% by weight of nickel, 30% by weight of iron and 3% by weight of boron was used. The average particle size was 40 μm . This master alloy powder was mixed with a weight share of 4% with a sintering powder on the basis of iron having 0.3% by weight of carbon. The powder mixture was pressed into a cylindrical formed body with a green density of 7.160 g/cm³ and thereafter sintered at a temperature of 1250°C under a hydrogen atmosphere. After the sintering, a density of 7.314 g/cm³ was measured. The impact strength was measured with 78.24 J/cm².

In a further embodiment, a master alloy powder with 63% by weight of nickel, 30% by weight of iron and 7% by weight of boron with an average particle size of 60 μm were used, in a quantity of 2% by weight in the entire powder mixture. The sintering powder on the basis of iron had a carbon content of 0.3% by weight. In a treatment corresponding to the above embodiment, a green density of 7.068 g/cm³ and a sintered density of 7.228 g/cm³ were measured. The impact strength was 76.21 J/cm².

In the stated mixture ratios, the nickel share in the sintered steel was 2.68% by weight in the first embodiment and the share of boron was 0.12% by weight, corresponding to a ratio of nickel to boron of approximately 22:1. In the second embodiment, the obtained share of nickel was 1.26% by weight and that of boron was 0.14% by weight. The ratio of nickel to boron could thus be stated with 9:1.

Brief description of the drawings

The drawing shows the dependence of the impact strength on the boron content in a method in accordance with the invention on the basis of two master alloy powders.

Description of the preferred embodiment

Curve 1 relates to a master alloy powder with 67% by weight of nickel, 30% by weight of iron and 3% by weight of boron. This master alloy powder was added to the sintering powder in different quantities. After sintering under the conditions of the embodiments, the impact strength of the different molded bodies having different boron shares was measured. Curve 1 shows the principal progress of the impact strength depending on the values of the boron content as entered in percent by weight on the absciss. The magnitude of the impact strength is co-determined by the composition of the sintering powder, so that the drawing only shows the principal dependence of the impact strength on the boron content, but no specific measured values for the impact strength. It can be seen that the impact strength reaches a maximum in the region of the boron content of between 0.13 and 0.15% by weight of the sintered steel. Thereafter it drops strongly towards the higher boron shares.

Curve 2 shows the measured values which are obtained in the use of a master alloy powder with 63% by weight of nickel, 30% by weight of iron and 7% by weight of boron according to the second embodiment. In the determination of curves 1 and 2, merely the weight shares of the master alloy powder in the powder mixture were changed. All other parameters were left unchanged. It can be seen from the two curves 1 and 2 that more favorable conditions concerning the impact strength of the molded body are obtained over a wider range for the master alloy powder with the higher nickel and lower boron share. Both curves also show that at a boron content of larger than 0.2% by weight the impact strength will decrease rapidly and therefore only a boron content of up to 0.2% by weight will lead to a respectively high impact strength.